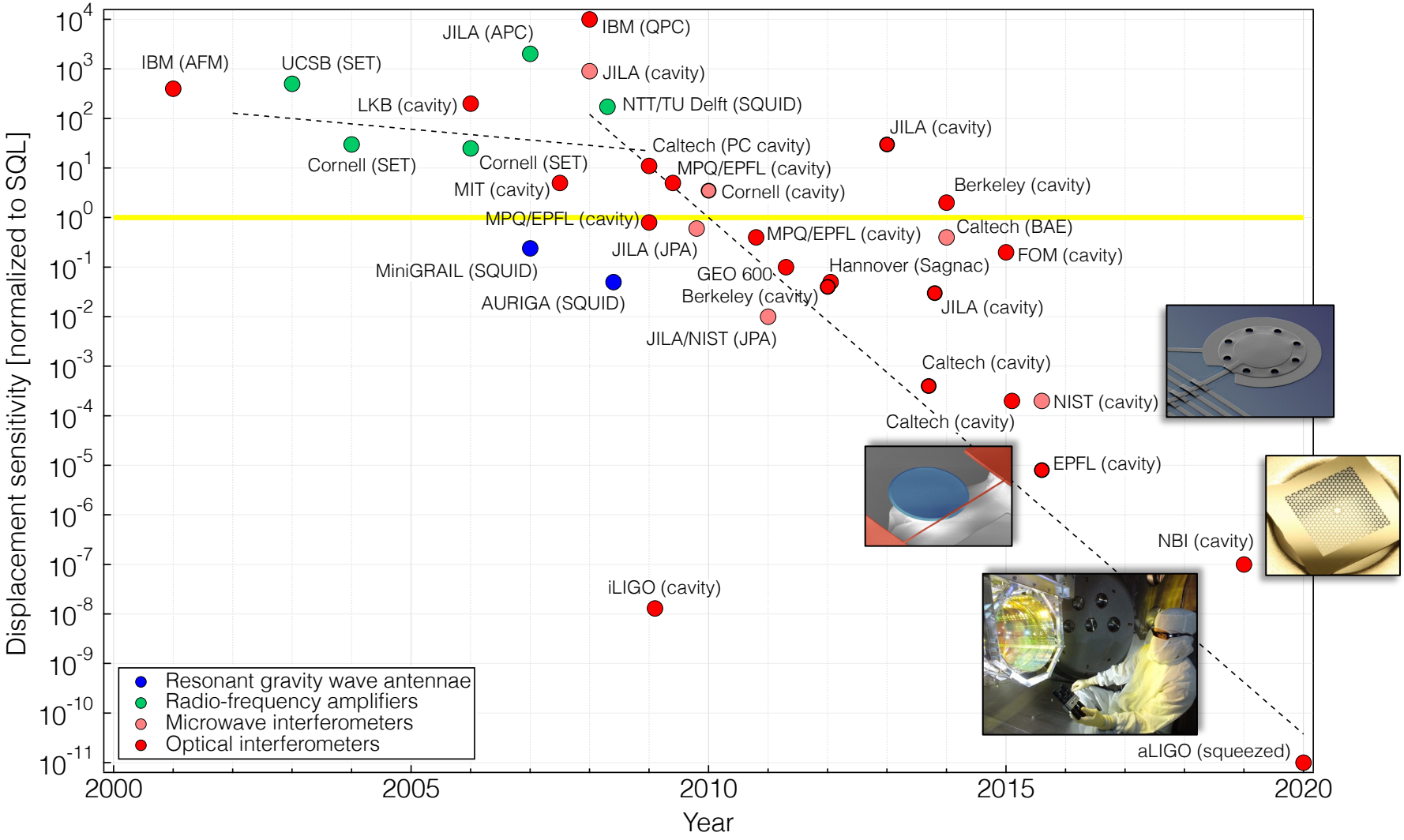
Mechanical tests of the gravity-quantum interface

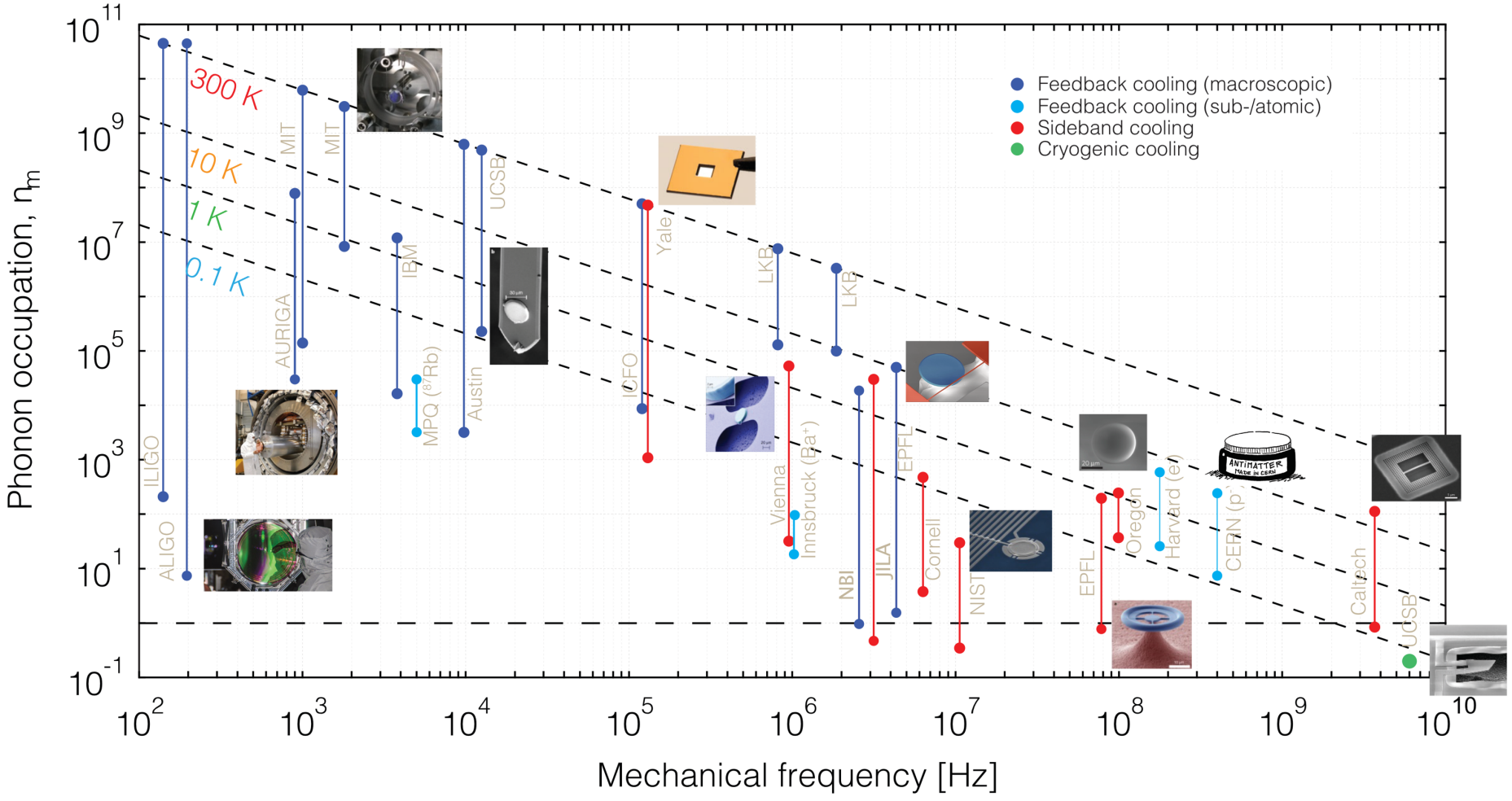
Vivishek Sudhir

MIT

Sub-SQL monitoring of mechanical motion



Preparation of quantum states of mechanical motion

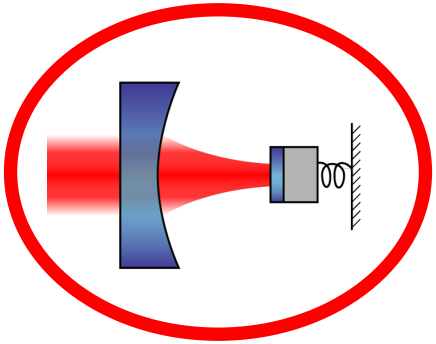


Idea of LoI: use sub-SQL precision for fundamental tests

Tests of Newtonian gravity at small mass/distance

Planck-mass-scale physics

$$\Delta x \cdot \Delta p \geq \frac{\hbar}{2}\left[1 + \beta\left(\frac{M}{M_P}\right)^2\left(\frac{\Delta v}{c}\right)^2\right]$$



Gravitational entanglement and decoherence

Quantum mechanics in non-inertial frames

$$T_U \sim \frac{\hbar a}{k_B c}$$

Requirements

- **Benchmarks:**
  - Massive ($M > M_P \approx 26\ \mu g$) mechanical oscillators measured at their motional ground state
  - Ultra-high-frequency oscillators (single electron?) in deep cryogenic environment ($\sim 10\ mK$) measured with sub-SQL precision
- Low-environment-noise cryogenic facility (being developed at MIT)
- Techniques to measure single electron motion in a quantum-noise-limited manner

Plans for Snowmass21

- Feasibility studies (→ contributed papers)
- Collaboration with HEP community to understand SRF cavity technology

- Detailed theoretical understanding of systematics
- Begin development of experiments

What do we hope to get out of Snowmass?

- Collaboration with HEP community to
  - understand and translate technologies of interest
  - contextualize precision experiments at the gravity-quantum interface